

Claims

- [c1] 1. A powertrain for a hybrid electric vehicle including an engine, an electric generator and an electric motor acting as a pair of power sources, the powertrain comprising: gear elements establishing power delivery from the power sources to vehicle traction wheels; the gear elements drivably connecting independently each power source to the traction wheels through first and second geared power flow paths; and a vibration damper assembly disposed between the motor and the gear elements, the damper assembly attenuating inertia torque fluctuation and torsional vibration as motor torque is delivered to the vehicle traction wheels.
- [c2] 2. A powertrain for a hybrid electric vehicle as set forth in claim 1 wherein:
the first geared power flow path is defined by a first gear unit;
a second gear unit;
the first gear unit having a sun gear connected to the generator, a carrier connected to the engine and a ring gear connected drivably to a second gear unit;
the engine defining one power source on an engine axis

and the motor defining in part another power source on a motor axis; and
a clutch and brake friction element sub-assembly for the second planetary gear unit establishing selectively multiple gear ratios;
the driving connection between the motor and the traction wheels being through fixed ratio gear elements and the second gear unit being connected drivably to the traction wheels to complement motor driving power;
the driving connection between the motor and the traction wheels comprising a vibration damper assembly disposed between the motor and the second gear unit, whereby inertia torsional vibrations are attenuated.

- [c3] 3. The powertrain set forth in claim 2 wherein the first gear unit and the second gear unit are disposed on a common axis coinciding with the engine axis.
- [c4] 4. The powertrain set forth in claim 2 wherein the first gear unit is disposed on the engine axis and the second gear unit is disposed on an axis that is offset from and parallel to the engine axis.
- [c5] 5. A powertrain for a hybrid electric vehicle having an engine, an electric generator and an electric motor defining a pair of power sources, the powertrain comprising:

a planetary gear unit with a first planetary element connected drivably to the generator and a second planetary element connected drivably to the engine whereby a first power flow path to vehicle traction wheels is established; a geared connection between the motor and the vehicle traction wheels, the geared connection defining a second power flow path that is independent of the first power flow path while sharing at least one gear element; a clutch and brake friction element sub-assembly selectively establishing each of two gear ratios in the planetary gear unit; and a vibration damper assembly disposed between the motor and the geared connection between the motor and the vehicle traction wheels, the vibration damper assembly including damper springs and motor inertia mass.

[c6] 6. The powertrain set forth in claim 5 wherein the geared connection comprises:

a countershaft on a countershaft axis spaced from and parallel to an axis for the engine and an axis for the motor;

the planetary gear unit having a high ratio power output gear element and a low ratio power output gear element; and

a selectively engageable clutch on the countershaft axis to connect selectively the high ratio power output gear

element and the low ratio power output gear element to the vehicle traction wheels.

[c7] 7. The powertrain set forth in claim 6 wherein the countershaft has two gear elements of different pitch diameter;

the selectively engageable clutch on the countershaft axis connecting drivably the smaller of the two countershaft gear elements to the vehicle traction wheels to establish a first countershaft gear ratio;

the larger of the two countershaft gear elements being connected drivably to the vehicle traction wheels to establish a second countershaft gear ratio when the selectively engageable clutch on the countershaft axis is open.

[c8] 8. A powertrain for a hybrid electric vehicle having an engine, an electric generator and an electric motor, the powertrain comprising:

a first planetary gear unit on an axis that is common to an engine axis, the engine being connected drivably to a torque input element of the first planetary gear unit;

a second planetary gear unit on a countershaft axis spaced from and parallel to both the engine axis and an electric motor axis, a torque output element of the second planetary gear element being connected drivably to vehicle traction wheels;

a torque input element of the second planetary gear unit being connected drivably to a torque output element of the first planetary gear unit;

a clutch and brake friction element sub-assembly establishing and disestablishing each of two gear ratios in the second gear unit whereby a ratio change occurs in a power flow path for the motor; and

a vibration damper assembly including damper springs and motor inertia mass disposed between the motor and the second planetary gear unit, whereby inertia torsional vibrations are attenuated.

- [c9] 9. A powertrain for a hybrid electric vehicle having an engine, an electric generator, an electric motor and a planetary gear unit on an engine axis, the powertrain comprising:
- a driving connection between the engine and a first element of the planetary gear unit, the generator being connected drivably to a second element of the planetary gear unit;
- countershaft gearing comprising two countershaft gear elements mounted on a countershaft axis spaced from and parallel to a motor axis and the engine axis;
- countershaft clutch means for establishing and disestablishing each of two gear ratios in the countershaft gearing;

the countershaft clutch means selectively connecting each countershaft gear element to vehicle traction wheels;
the motor being drivably connected through the countershaft clutch means to the countershaft gears and a torque output element of the planetary gear unit being drivably connected to the countershaft gearing through the countershaft clutch means; and
a vibration damper assembly disposed between the motor and the countershaft gearing, whereby inertia torsional vibrations are attenuated.

- [c10] 10. A powertrain for a hybrid electric vehicle having an engine, an electric generator, and an electric motor, the powertrain comprising:
a planetary gear unit on an engine axis;
the engine being connected drivably to a first element of the planetary gear unit, the generator being connected drivably to a second element of the planetary gear unit;
countershaft gearing comprising at least two countershaft gear elements mounted on a countershaft axis spaced from and parallel to a motor axis and the engine axis;
countershaft clutches for selectively connecting each of the countershaft gear elements to vehicle traction wheels;

the motor being drivably connected through the countershaft clutches to the countershaft gears and a torque output element of the planetary gear unit being drivably connected to the countershaft gearing through the countershaft clutches; and
a vibration damper assembly including damper springs disposed between the motor and the second planetary gear unit, whereby inertia of the mass of the motor rotor and the damper springs attenuate torsional vibrations.

[c11] 11. The powertrain set forth in claim 10 wherein the countershaft clutches comprise multiple clutch elements in each of the power flow paths whereby engine power is available to complement motor power during a gear ratio change in the power flow path for the motor and motor power is available to complement engine power during a gear ratio change in the power flow path for the engine, thus effecting smooth gear ratio changes in the powertrain.

[c12] 12. A powertrain for a hybrid electric vehicle having an engine, an electric generator and an electric motor, the powertrain comprising:
a first planetary gear unit on an axis that is common to an engine axis, the engine being connected drivably to a torque input element of the first planetary gear unit, the first planetary gear unit defining a first power flow path

for the engine for driving the vehicle traction wheels;
a second planetary gear unit with a clutch and brake
friction element sub-assembly for establishing and dis-
establishing each of two gear ratios in a second power
flow path for the motor for driving the vehicle traction
wheels; and

a vibration damper assembly, including damper springs
and motor inertia mass, disposed between the motor
and the second planetary gear unit, whereby inertia tor-
sional vibrations are attenuated.